

DYNAMIC TERM-BY-TERM STABILIZED FINITE ELEMENT FORMULATION FOR INCOMPRESSIBLE FLOWS

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ABSTRACT. In this work, we present and analyze the stability and the dissipative structure of a recently proposed dynamic term-by-term stabilized finite element formulation for the Navier-Stokes problem that can be viewed as a variational multiscale (VMS) method under some assumptions [1]. Our approach follows the term-by-term stabilization proposed in [2] for viscoelastic fluid flows, which has been demonstrated more effective when there are pressure singularities. The essential point of the formulation is the time dependent nature of the subscales and, contrary to residual-based formulations, the introduction of two velocity subscale components. They represent the components of the convective and the pressure gradient terms, respectively, of the momentum equation that cannot be captured by the finite element mesh. A key idea of the proposed method is that the convective subscale is close to a solenoidal field and the pressure gradient subscale is close to a potential field. The method ensures stability in anisotropic space-time discretizations, which is proved using numerical analysis under suitable assumptions and demonstrated in classical numerical tests. The work includes a detailed description of the proposed formulation and several numerical examples are using to show the robustness and accuracy of the method.

Keywords: Stabilized Finite Element Methods, Variational Multiscale, Dynamic Subscales, Term-by-Term Stabilization.

Mathematics Subject Classifications (2010): 65N06, 65N12

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REFERENCES

- [1] Ernesto Castillo and Ramon Codina: Dynamic term-by-term stabilized finite element formulation using orthogonal subgrid-scales for the incompressible Navier-Stokes problem. *Submitted to Computer Methods in Applied Mechanics and Engineering*, (2018).
- [2] Ernesto Castillo and Ramon Codina: Variational multi-scale stabilized formulations for the stationary three-field incompressible viscoelastic flow problem. *Computer Methods in Applied Mechanics and Engineering*, 279, 579–605, (2014).

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